LANDSAT 7 SYSTEM

IMAGE ASSESSMENT SYSTEM ELEMENT SPECIFICATION

IN WORK

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1.0 SCOPE

This document contains the element level functional, performance, operational, and interface requirements for the Image Assessment System (IAS) **in section 3.2**. These requirements are traceable to the Landsat 7 System Specification (Applicable Document #1), and were derived by the Landsat 7 Project Science Office in conjunction with the interagency Landsat Science Quality Assurance Team (LSQAT). **Section 3.7 contains the element design requirements for software. The hardware design requirements are not included in this version. The IAS element has been described as having seven software components and requirements have been allocated to those components in section 3.7. Section 4.0 consists of the requirements verification matrix listing all 3.2 requirements and their method of verification.**

2.0 APPLICABLE DOCUMENTS

1. National Aeronautics and Space Administration (NASA) Earth Science Mission Operations Landsat 7 System Specification, GSFC, 430-L-0002-F

2. Landsat-7 Image Assessment System Operations Concept, GSFC, September 13, 1994.

3. Landsat-7 Program Coordinate System Standard, GSFC, *

4. Landsat-7 System and Operations Concept, October 13, 1994.

5. Space Segment Calibration Plan, Martin Marietta Astro Space, CDRL No. A104, August 26, 1994.

6. Landsat-7 MOC to IAS Interface Control Document.

7. Interface Control Document Between the IAS and the LPS, 514-1ICD/0195.

8. Interface Control Document between ECS and the Landsat 7 System, 209-CD-013-002

3.0 REQUIREMENTS

3.1 ELEMENT DEFINITION

The Image Assessment System (IAS) is an element of the Landsat-7 Ground Data Handling Segment, and is responsible for off-line assessment of image quality to ensure compliance with the radiometric and geometric requirements of the spacecraft and the ETM+ sensor throughout the mission's life.

In addition to its assessment functions, the IAS is also responsible for the radiometric and geometric calibration of the Landsat 7 satellite and ETM+. Initial calibration data, in addition to sensor characteristics and models are received pre-launch from the ETM+ contractor (SBRC**S**) and the Space Segment Satellite(~~MMAS~~**LMMS**). The IAS periodically performs radiometric and geometric calibration and passes calibration coefficient updates directly to the Land Processes Distributed Active Archive Center (LPDAAC) and to IGSs

through the MOC. Anomalies are reported to the Mission Operations Center (MOC), Landsat Processing System (LPS), LPDAAC, and **Mission** Management Office (**M**MO) **as needed**.

The IAS obtains Level 0R data and products from the LPDAAC. These data include ancillary information such as ~~browse and~~ metadata. The IAS assesses image data ~~in raw form, or~~ **b y** process**ing** the data to Level 1R and 1G for assessment as Level 1 products. Image data are assessed with respect to their geometric and radiometric qualities on an individual sample and long term trending basis. Data quality assessments, reports, and improved processing instructions are sent to the LPDAAC, LPS, MOC, and the **M**MO.

3.2 IMAGE ASSESSMENT SYSTEM (IAS) REQUIREMENTS

3.2.1 INTERFACE REQUIREMENTS

3.2.1.1 LPDAAC

3.2.1.1.1 The IAS shall interface with the LPDAAC for purposes of priority searching for and ordering of data from the Landsat 7 archive.

3.2.1.1.2 The IAS shall ~~electronically~~ receive Level 0R Data, Level 0R Products and associated ancillary/metadata from the LPDAAC.

3.2.1.1.3 The IAS shall interface with the LPDAAC to coordinate the transfer of calibration ~~table updates, MTFC weights, problem reports, and data quality assessments.~~ **parameter files and IAS generated reports.**

3.2.1.1.4 The IAS shall electronically send calibration ~~coefficient updates , MTFC weights, problem reports, data quality assessments~~ **parameter files, IAS generated reports and their respective metadata to the LP-DAAC.**

~~3.2.1.1.5 The IAS shall recevie data quality assessment and problem reports from the LP-DAAC.~~

3.2.1.2 LPS

3.2.1.2.1 The IAS shall interface with the LPS to coordinate the transfer of data ~~quality assessments and problem reports.~~ **calibration parameter files and reprocessing requests.**

3.2.1.2.2 The IAS shall send ~~data quality assessments and problem reports~~ **reprocessing requests** to the LPS ~~electronically~~.

3.2.1.2.3 The IAS shall receive ~~data quality and anomoly identification reports~~ **disposition of reprocessing requests** from the LPS.

3.2.1.2.4 The IAS shall send **calibration** parameter **files** updates to the LPS.

3.2.1.3 MOC

3.2.1.3.1 The IAS shall provide to the MOC a schedule for the operational acquisition of partial aperture calibration data, full aperture calibration data, and surface image data of radiometric and geometric calibration ground sites.

3.2.1.3.2 The IAS shall coordinate with the MOC for the acquisition of additional ETM+ imagery required for calibration and image assessment.

3.2.1.3.3 The IAS shall interface with the MOC to coordinate the transfer of problem reports, ~~status reports, data quality assessments~~, and calibration **parameter files** updates.

3.2.1.3.4 The IAS shall ~~electronically~~ send problem reports~~, status reports, and data quality assessments~~ to the MOC.

3.2.1.3.5 The IAS shall electronically ~~provide~~ **send** calibration ~~updates~~ **parameter files and calibration requests** to the MOC.

3.2.1.3.6 The IAS **shall** be capable of ~~retrieving~~ **receiving** ~~the results of~~ telemetry **trend reports and spacecraft status reports** ~~processing and subsystem analysis (e.g. trends and observed problems)~~ from the MOC.

3.2.1.3.7 The IAS shall be capable of receiving FDF generated, definitive ephemeris from the MOC.

3.2.1.4 ~~PROGRAM~~ MISSION MANAGEMENT OFFICE

3.2.1.4.1 The IAS shall send problem reports, ~~status reports, and data quality assessments~~ **and summary reports** to the ~~Program~~ **Mission** Management Office.

~~**3.2.1.4.2** The IAS shall receive special acquisition requests from the PMO (project scientist).~~

3.2.2 FUNCTIONAL REQUIREMENTS

3.2.2.1 Radiometric Calibration

3.2.2.1.1 The IAS shall be able to utilize data from the internal calibrator in the calibration of the radiometric response of each ETM+ detector.

3.2.2.1.2 The IAS shall be able to calibrate the radiometric response of each ETM+ detector, except band 6, using data from the partial aperture solar calibrator.

3.2.2.1.3 The IAS shall be able to calibrate the radiometric response of each ETM+ detector, except band 6, using data from the full aperture solar calibrator.

3.2.2.1.4 The IAS shall be able to calibrate the radiometric response of each ETM+ detector given Level 0R data of a ground calibration site and corresponding at-aperture spectral radiance values.

3.2.2.1.5 The IAS shall be able to calibrate the radiometric response of each ETM+ detector using level 0R data from pre-ship and pre-launch calibration sources and auxiliary calibration source data.

3.2.2.1.6 The IAS shall have the capability of assessing the short and longterm stability of the on-board calibration sources which include the full aperture solar calibrator, partial aperture solar calibrator, and the internal calibrators.

3.2.2.1.7 The IAS shall be able to integrate the results of the various calibration processes into an optimal estimate of radiometric calibration of each detector (except band 6) and provide new calibration parameters.

3.2.2.1.8 The IAS shall be capable of generating radiometric calibration updates and their associated metadata.

3.2.2.1.9 The IAS shall be able to transfer the calibration of each detector to the internal calibrator.

3.2.2.2 Geometric Calibration

3.2.2.2.1 The IAS shall be capable of determining the misalignment between the satellite navigational base reference and the ETM+ payload line-of-sight.

3.2.2.2.2 The IAS shall be capable of determining band to band registration parameters.

3.2.2.2.3 The IAS shall be capable of characterizing and updating along and across scan parameters (i.e. scan mirror profiles, scan-line corrector mirror profile, detector offsets, detector delays).

3.2.2.2.4 The IAS shall be capable of generating geometric calibration updates and their assoicated metadata.

3.2.2.3 Level 1 Processing

3.2.2.3.1 The IAS shall be capable of processing PCD data.

3.2.2.3.2 The IAS shall be capable of processing ETM+ Level 0R products to produce radiometrically corrected Level 1R image data.

3.2.2.3.3 The IAS shall be capable of creating systematically corrected ETM+ Level 1G imagery from level 0R products.

3.2.2.3.4 The IAS shall be capable of creating precision corrected ETM+ Level 1G imagery from level 0R products and ground control points.

3.2.2.3.5 The IAS shall be capable of creating terrain corrected ETM+ Level 1G imagery from level 0R products, ground control points, and elevation data.

3.2.2.3.6 The IAS shall be capable of performing image to image registration.

3.2.2.3.7 The IAS shall be capable of incorporating IAS generated calibration coefficient updates to generate Level 1 data.

3.2.2.3.8 The IAS shall support nearest neighbor, cubic convolution, and MTF compensation resampling.

3.2.2.3.9 The IAS shall have the capability to produce a 1G product with a grid cell size that is continuously variable from 15 to 60 meters.

3.2.2.3.10 The IAS shall have the capability to map project 1G using the Space Oblique Mercator, Universal Transverse Mercator, Lambert Conformal Conic,

Transverse Mercator, Oblique Mercator, and Polyconic coordinate reference systems.

3.2.2.3.11 The IAS shall have the capability to create a 1G image oriented to nominal path or north-up.

3.2.2.3.12 The IAS shall be capable of receiving and ~~generating~~ **archiving** GCPs and GCP chips.

3.2.2.3.13 The IAS shall be capable of compensating for inoperable detectors during level 1R and 1G processing.

3.2.2.3.14 The IAS shall be capable of compensating for image artifacts including but not limited to streaking, banding, and pan coherent noise during level 1R and 1G processing.

3.2.2.3.15 The IAS shall be capable of processing to Level 1R and 1G both ascending and decending pass ETM+ Level 0R data.

3.2.2.3.16 The IAS shall be capable of processing non-nominal data (e.g. backwards time jumps, data gaps).

3.2.2.4 Performance Evaluation

3.2.2.4.1 The IAS shall evaluate the on-orbit operability of ETM+ detectors.

3.2.2.4.2 The IAS shall be able to evaluate the absolute radiometric accuracy of ETM+ Level 0R, 1R and 1G data.

3.2.2.4.3 The IAS shall be able to assess identified ETM+ radiometric image artifacts including but not limited to streaking, banding, correlated and coherent noise, scan line droop, and bright target recovery response.

3.2.2.4.4 The IAS shall be able to evaluate the MTF of each ETM+ detector.

3.2.2.4.5 The IAS shall be able to evaluate the signal to noise ratio of each ETM+ detector, utilizing pre-launch and on-orbit image data.

3.2.2.4.6 The IAS shall be capable of evaluating the on-orbit radiometric response of each ETM+ detector with respect to dynamic range.

3.2.2.4.7 The IAS shall be capable of evaluating the on-orbit radiometric response of each ETM+ detector excluding band 6 with respect to linearity (TBD).

3.2.2.4.8 The IAS shall be able to evaluate the geodetic accuracy of ETM+ Level 1G image data.

3.2.2.4.9 The IAS shall be able to evaluate the internal geometric accuracy of ETM+ Level 1G image data.

3.2.2.4.10 The IAS shall be able to evaluate the band to band registration accuracy of ETM+ imagery.

3.2.2.4.11 The IAS shall be able to evaluate the image to image registration accuracy of ETM+ data.

3.2.2.4.12 The IAS shall be able to evaluate the quality of level 0R products. Quality checks will include but not be limited to thosed listed in Table 3.2.2.4-1.

Imagery	**Cal Parameter File**
Visual Check	Applicability date consistent with imagery
Process to 1R/1G	Consistency with IAS Database
Payload Correction Data	**Metadata**
Range check all but housekeeping	ACCA scores (visual check)
Validated in 1G model	Scene coordinates
	File name consistency
Mirror Scan Correction Data	WRS scene parameters correctness (sun angles, scen center lat/long, asc/desc flag, etc).
Validated in 1G model	**Cal Pulse/ Shutter**
Scan direction consistency	Cal outliers
FHSEER/SHSERR consistency	Shutter mean
Counted line leng. consistency	Shutter standard deviation
	Shutter outliers

Table 3.2.2.4-1 L0R Product Quality Checks

3.2.2.4.13 The IAS shall be capable of performing a trend analysis over any desired time interval for each selected evaluation activity.

3.2.2.4.14 The IAS shall be capable of performing (and/or supporting) other anomaly, assessment, resolution, and reporting.

3.2.2.4.15 The IAS shall provide the capability to visually inspect image data.

3.2.2.4.16 The IAS shall provide a capability that allows an image analyst to monitor assessment processes and results.

3.2.2.4.17 The IAS shall have the capability to review output data including but not limited to calibration reports and updates.

3.2.2.5 Incorporation of New Algorithms

3.2.2.5.1 The IAS shall have the capability to acquire, develop, test, and add new algorithms and software to improve the radiometric and geometric properties of ETM+ data and their assessment without impacting IAS operations.

3.2.2.5.2 The IAS shall support the development of algorithms to remove image artifacts and detector outages from Level 1R and 1G data.

3.2.2.5.3 The IAS shall have the capability to incorporate new algorithms into the operational system.

3.2.2.5.4 The IAS shall maintain configuration control of all algorithms, databases, software, and hardware used in operations.

3.2.2.6 Process Control and Manage Data

3.2.2.6.1 The IAS shall be capable of executing a set of processes defined as procedures.

3.2.2.6.2 The IAS shall be capable of archiving all software and databases used in operations.

3.2.2.6.3 The IAS shall be capable of storing selected data, parameters, reports, and documents.

3.2.2.6.4 The IAS shall have the ability to monitor and control processes and procedures.

3.2.2.6.5 The IAS shall be capable of storing selected GCPs, GCP chips, and associated metadata.

3.2.2.6.6 The IAS shall be capable of receiving and storing selected DEMs.

3.2.2.6.7 The IAS shall be capable of archiving selected online data, parameters, and ancillary data.

3.2.2.6.8 The IAS shall be capable of receiving and storing solar spectral and broadband radiance data from external sources.

3.2.2.6.9 The IAS shall be capable of receiving and storing sun radiance data from external sources.

3.2.2.6.10 The IAS shall be capable of receiving and storing cross calibration data from other sensors.

3.2.2.6.11 The IAS shall archive selected pre-launch data including but not limited to sensor enginneering, ETM+ image data, alignment matrices, calibration measurements, mirror scan profiles, FASC BRDF, relative spectral sub-system response on a detector by detector basis, and required characterization data for performing in-flight calibrations.

3.2.2.7 Reports & Summaries

3.2.2.7.1 The IAS shall generate calibration, data quality assessment, and problems reports for the various interfaces.

3.2.2.7.2 The IAS shall be capable of generating metadata for all reports sent to the LP-DAAC.

3.2.2.7.3 The IAS shall generate annual reports that document calibration coefficient and performance analysis trends.

3.2.2.7.4 The IAS shall generate reports of anomaly detection analyses as they appear.

3.2.2.7.5 The IAS shall generate processing summaries after each IAS activity.

3.2.3 PERFORMANCE REQUIREMENTS

Accuracy

3.2.3.1 The IAS shall be capable of calibrating the radiometric response (absolute spectral radiance) of each operable ETM+ detector to an accuracy of 5%, 1 sigma, providing all inputs are within specification.

3.2.3.2 The IAS shall be capable of calibrating the relative radiometric response such that the ratio of ETM+ equivalent at-aperture radiances between any combination of two spectral bands, excluding band 6, shall vary less than 2%, 1 sigma, over a 7 day period when exposed to a spectrally constant source.

3.2.3.3 The IAS shall contribute no greater than .7% uncertainty to absolute radiometric accuracy during the generation of level 1R and 1G data.

3.2.3.4 The IAS shall be able to create systematic imagery to a geodetic accuracy of 250 meters, 1 sigma, providing all inputs are within specification. Performance applies to along-track and cross-track directions, and is referenced to a nadir-viewing geometry.

3.2.3.5 The Level 1 Processor shall contribute circular errors no greater than 1.8 m, 1 sigma, in the production of systematically corrected ETM+ Level 1G imagery. This error is referenced to a nadir viewing geometry and excludes the effect of terrain correction.

3.2.3.6 The IAS shall provide the capability to register pixels from a band to the corresponding pixels of the other bands in a common scene to an accuracy of 0.28 sensor GSD, .9p, in along-track and cross-track directions providing all inputs are within specification. The accuracy is relative to the largest sensor GSD of the registered bands.

3.2.3.7 The Level 1 Processor shall contribute error no greater than .11 multispectral sensor GSD, .9p, along-track, and .24 multispectral sensor GSD, .9p, cross-track in the assessment of band-to-band registration.

3.2.3.8 The IAS shall provide the capability to perform image to image registration to an accuracy of 0.4 multispectral sensor GSD, .9p, in the along-track and cross-track directions providing all inputs are within specification.

3.2.3.9 The Level 1 Processor shall contribute circular errors no greater than 3.6 m, 1 sigma, during image to image registration correction of ETM+ Level 1G data. Error is referenced to a nadir viewing geometry and excludes the effect of terrain correction.

3.2.3.10 The IAS shall be capable of estimating the field angles to an accuracy of .18 arcsec, 1 sigma.

3.2.3.11 The IAS shall be capable of digitally correlating common features in separate bands of the same image or same bands of separate images to an accuracy of 0.1 pixel, .9p.

3.2.3.12 The IAS shall be capable of estimating the alignment of the ETM+ line-of-sight to the satellite navigation base reference to an accuracy of 24 arcsec, 1 sigma, in all axes.

~~**3.2.3.13** The IAS shall create GCPs to an accuracy of 1/5 pixel.~~

Throughput

3.2.3.14 The IAS shall be capable of generating the equivalent of up to 10 ETM+ Level ~~1R or 10~~ 1G ~~precision~~ **systematically** corrected scenes in an 8 hour day over the life of the mission. **(Note: this requirement is meant to size the maximum capacity of the system.)**

3.2.3.15 The IAS shall be capable of receiving and storing up to 10 GB per day of data from the LP-DAAC.

3.2.3.16 The IAS shall be capable of archiving a total of 20,000**(TBR)** Landsat-7 Level 0R equivalent scenes over the life of the mission.

3.2.3.17 The IAS shall generate monthly reports that document the quality of 0R data and 0R products retrieved from the LP-DAAC.

3.2.4.18 The IAS shall provide regular calibration and performance updates to the LP-DAAC and other interfaces on a quarterly basis.

3.2.4.19 The IAS shall provide an annual Landsat-7 image quality report.

3.2.3.20 The IAS shall have an online data storage capacity of 100 GB (TBR).

3.2.3.21 The IAS shall be capable of storing GCP data (points, chips, metadata) of at least 68 MB.

3.2.3.22 The IAS shall capable of archiving 20 GB of elevation data.

3.2.4 OPERATIONAL REQUIREMENTS

3.2.4.1 The IAS shall be staffed with an operator, two image analysts, software maintenance personnel, and an IAS manager (TBR).

3.2.4.2 The IAS shall support end-to-end testing at least 12 (TBR) months prior to launch.

3.2.4.3 The IAS shall be capable of supporting full operations at launch -6 months.

3.2.4.4 The IAS shall support mission operations for a minimum of 5 years following in-orbit check-out (IOC).

3.2.4.5 The IAS shall operate two shifts for seven days a week during IOC plus 48 days (TBR).

3.2.4.6 The IAS shall be staffed during prime shift post IOC plus 48 days (TBR).

3.2.4.7 The IAS shall ensure backup of all online data and operations software.

3.2.4.8 The IAS shall perform calibrations, assessments and evaluations with frequencies specified in Tables 3.2.4-1 and 3.2.4-2.

Calibration Activity	Activity Frequency	ReportingFrequency
Sensor Alignment Calibration	Once during IOC and at no more than 90 day intervals	Quarterly
Band to Band Registration	Once during IOC and at no more than 90 day intervals	Quarterly
Detector Delay Calibration	Once during IOC and at no more than 90 day intervals	Quarterly
Radiometric Calibration	Once during IOC and at no more than 90 day intervals	Quarterly

Table 3.2.4-1 Frequency of Calibration Activities

3.2.4.9 The IAS shall have the capability to maintain and upgrade all operational software.

3.2.4.10 The IAS shall be capable of supporting training without impacting daily work loads.

Assessments	Assessment Frequency	Reporting Frequency
Detector Operability	Once during IOC and at most each time FASC image collected	Quarterly
Radiometric Accuracy	Once during IOC and at most on 90 day intervals	Quarterly
Streaking and Banding	Once during IOC and at most on 90 day intervals	Quarterly
Correlated and Coherent Noise	Once during IOC and at most each time FASC image collected	Quarterly
MTF	Once during IOC and at most on 90 day intervals needs MTF ground targets	Quarterly
SNR	Once during IOC and at most each time FASC image collected	Quarterly
Geodetic Accuracy	At most on 90 day intervals	Quarterly
Geometric Accuracy	At most on 90 day intervals	Quarterly
Band to Band Registration Accuracy	At most on 90 day intervals	Quarterly
Image to Image Registration Accuracy	At most on 90 day intervals	Quarterly
Image Artifacts	At most on 90 day intervals	Quarterly
Evaluation	**Evaluation Frequency**	**Reporting Frequency**
LPS Data Quality	Every 30 days	Monthly and Annually
Level 0R Data and Products	Daily	Monthly and Annually
Level 1R Data Quality	Every 30 days	Quarterly and Annually
PCD Quality	Every 30 days	Monthly and Annually
Selected Trend Analyses	Annually	Annually

Table 3.2.4 -2 Frequency of Assessment and Evaluation Activities (TBR)

3.2.4.11 The IAS shall provide an Operational Availability of 0.85 (TBR) or better for all processing functions .

3.2.4.12 The IAS shall support a mean time to restore (MTTR) capability of 12 (TBR) hours or better.

3.3 DESIGN & CONSTRUCTION

3.4 DOCUMENTATION (N/A)

3.5 LOGISTICS (N/A)

3.6 PERSONNEL AND TRAINING (N/A)

3.7 ALLOCATED ELEMENT DESIGN REQUIREMENTS

3.7.1 Control Processes and Manage Data

3.7.1.1 CP&MD component shall have a telephone capability for interface coordination with the LPDAAC, LPS, MOC and MMO.

3.7.1.2 The CP&MD component shall interface with the LPDAAC as described in the Interface Control Document between ECS and the Landsat 7 System, 209-CD-013-002

3.7.1.3 The CP&MD component shall interface with the LPS as described in the Interface Control Document Between the IAS and the LPS, 514-1ICD/0195.

3.7.1.4 The CP&MD component shall interface with the MOC as described in the Landsat 7 MOC to IAS Interface Control Document, #

3.7.1.5 The CP&MD component shall have the capability to perform an interactive dialog search of the LPDAAC archive.

3.7.1.6 The CP&MD component shall have the capability to send reports to the MMO.

3.7.1.7 The CP&MD component shall have the capability to predict Landsat 7 orbit paths and sun angles.

3.7.1.8 The CP&MD component shall define the image processing parameters IAS will use for the scene, upon order from the LPDAAC.

3.7.1.9 The CP&MD component shall perform planning and scheduling of IAS tasks and resources.

3.7.1.10 The CP&MD component shall be capable of detecting, handling, and logging system and data errors.

3.7.1.11 The CP&MD component shall be capable of receiving, retreiving, and ingesting 0R product data from LPDAAC.

3.7.1.12 The CP&MD component shall be capable of receiving, retreiving and ingesting 0R product data from the LPS.

3.7.1.13 The CP&MD component shall have the ability to save, identify, list, search, and retreive all data items and parameters generated by the IAS.

3.7.1.14 The CP&MD component shall be capable of receiving and archiving pre-launch, elevation , GCP, cross calibration, ground look, sun radiance, solar spectral, and broadband radiance data from external sources.

3.7.1.15 The CP&MD component shall be capable of correcting OR product data times for on-board clock drifts.

3.7.1.16 The CP&MD component shall be capable of extracting and validating FHSERR, SHSERR, scan direction and start times from the Mirror Scan Correction Data (MSCD).

3.7.1.17 The CP&MD component shall be capable of validating and converting to engineering units, the Payload Correction Data (PCD).

3.7.1.18 The CP&MD component shall be capable of validating scene coordinates.

3.7.1.19 The CP&MD component shall generate and maintain a calibration parameter file for distribution to the LPS, LPDAAC, and the MOC.

3.7.1.20 The CP&MD component shall monitor IAS system status and IAS processing status.

3.7.1.21 The CP&MD component shall be capable of updating, testing and releasing IAS software as needed.

***3.7.1.22** The CP&MD component shall maintain configuration control of all algorithms, databases, software and hardware used in IAS operations. (Duplicate wording of 3.2.2.5.4 and DFD missing)

3.7.1.23 The CP&MD component shall interface with all other IAS components for monitoring processes and receiving status and data.

3.7.2 Process to Level 1 (PL1)

3.7.2.1 The PL1 component shall have the capability logically relate the internal calibrator (IC) data by scan line, with image data received in the Level 0R product.

3.7.2.2 The PL1 component shall have the capability to correct IC and image data for the effects of instrument memory effect.

***3.7.2.3** The PL1 component shall have the capability to correct image data for the effects of scan correlated shift, coherent noise and impluse noise. (IC data or not?)

3.7.2.4 The PL1 component shall have the capability to correct image data for dropped lines, inoperable and saturated detectors, and the effects of striping and banding.

3.7.2.5 The PL1 component shall have the capability to apply radiometric calibration to the 0R image data to produce 1R imagery.

3.7.2.6 The PL1 component shall have the capability to create a geometric model to relating PCD and MSCD to spacecraft position and pointing as a function of time.

***3.7.2.7** Generate input Grid function? Grid cell size to be variable (or selectable)

3.7.2.8 The PL1 component shall have the capability to calculate instrument line of sight and image latitudes and longitudes using the geometric model.

3.7.2.9 The PL1 component shall have the capability to generate a geometric grid of arbitraty mesh size for use in resampling.

***3.7.2.10** The PL1 component shall have the capability to resample using nearest neighbor, cubic convolution and MTF compensation. (Same as 3.2.2.3.8)

3.7.2.11 The PL1 component shall have the capability to vary the resampling cell size from 15 to 60 meters.

3.7.2.12 The PL1 component resampling method shall be selectable by operator/analyst.

3.7.2.13 The PL1 component shall have the capability to resample imagery in the along scan direction only.

3.7.2.14 The PL1 component shall have the capability to correct the precision model used to generate 1G images.

3.7.2.15 The PL1 component shall have the capability to create precision corrected 1G images of geometric test sites.

3.7.2.16 The PL1 component shall have the capability to process images using either the ephemeris generated by the spacecraft and received in the PCD of each image or the ephemeris calculated by the FDF and received from the MOC.

3.7.2.17 The PL1 component shall have the capability to correct 1G images of geometric test sites for terrain effects.

3.7.2.18 The 1G image map projections generated by the PL1 component shall be selectable by operator/analyst from the projections listed in 3.2.2.3.10.

3.7.2.19 The PL1 component shall have the capability to reframe benchmark matrices.

***3.7.2.20** The 1G image orientation generated by the PL1 component shall be selectable by the operator/analyst between nominal path or north-up. (note: why not arbitraty rotation angles?)

3.7.3 Perform Radiometric Calibration (PRC)

3.7.3.1 PRC component shall have the capability to process partial aperature solar calibrator (PASC) images, calculating dark values, solar values, and gain values for each detector, except for those in band 6.

3.7.3.2 PRC component shall have the capability to process full aperature solar calibrator (FASC) images, calculating incident angles, reflected solar radiance, FASC bright values, and gains for each detector not in band 6.

** I don't know what the right level is for PRC**

***3.7.3.3** The PRC component shall have the capability to calibrate the radiometric response of each ETM+ detector given Level 0R data of a ground calibration site and corresponding at-aperture spectral radiance values. (Verbatim 3.2.2.1.4)

***3.7.3.4** The PRC component shall have the capability to integrate the results of the various calibration processes into an optimal estimate of radiometric calibration of each detector and provide new calibration parameters. (Verbatim 3.2.2.1.7)

3.7.3.5 The PRC component shall have the capability to process pre-launch image data, both reflective and emissive bands, to generate detector gains and biases.

3.7.3.6 The PRC component shall have the capability to process internal calibrator data of both the reflective bands and the emissive band to generate detector gains and biases.

***3.7.3.7** The PRC component shall have the capability to transfer the calibration of any of the ETM+ calibration sources to any source. (Wording?)

3.7.4 Perform Geometric Calibration (PGC)

3.7.4.1 The PGC component shall have the capability to generate GCPs for geometric test sites.

***3.7.4.2** The PGC component shall have the capability to determine the misalignment between the satellite navigational base reference and the ETM+ payload line-of-sight. (Verbatim of 3.2.2.2.1) using ground control point chips for geometric test sites.
or
from attitude angle changes calculated to correct the precision model.

3.7.4.3 The PGC component shall have the capability to calculate detector delays and offsets in the along scan direction, to be included in the geometric processing parameters, using geometric test site images .

3.7.4.4 The PGC component shall have the capability to calculate detector offsets in the across scan direction.

***3.7.4.5** The PGC component shall have the capability to calculate scan-line corrector mirror motion errors (?using geometric test site images).

3.7.5 Characterize Radiometry (CR)

3.7.5.1 The CR component shall characterize data quality by locating and identifying impulse noise and dropped lines.

***3.7.5.2** The CR component shall characterize memory effect, a function of instrument quality, by estimating and validating a model of memory effect. (wording??)

3.7.5.3 The CR component shall characterize scan correlated shifts, a function of instrument quality, by identifying state changes in a characterized image and measuring state levels by detector in night images.

***3.7.5.4** The CR component shall characterize coherent noise, a function of instrument quality, by....

3.7.5.5 The CR component shall identify and locate saturated detectors, and characterize their effects.

***3.7.5.6** The CR component shall characterize the instrument MTF.
(similar wording to 3.2.2.4.4)

3.7.5.7 The CR component shall calculate the SNR and determine the status of each detector (nominal, degraded or dead).

3.7.5.8 The CR component shall have the capability to characterize random noise of an image.

3.7.5.9 The CR component shall have the capability to characterize the striping and banding of an image.

3.7.6 Characterize Geometry (CG)

***3.7.6.1** The CG component shall have the capabiltiy to calculate band-to-band registration accuracy, registration residuals, and detector field angles on systematically corrected 1G images .

Precision or accuracy of calculation?
Freqency?
Manual/automated?

***3.7.6.2** The CG component shall have an automated correlation capability that will correlate to .2 pixels on average ??

***3.7.6.3** The CG component shall have the capability to calculate image to image registration accuracy of any two geometrically corrected images.

Performace requirement?

3.7.6.4 The CG component shall have the capability to calculate the geodetic accuracy of geometrically corrected geometric test site images by using ground control points to determine location errors in the image.

3.7.7 Evaluate Performance (EP)

***3.7.7.1** The EP component shall have the capability to generate reports from data from all other components and from analyst inputs.

Fixed and free format reports
Max number of reports per day

***3.7.7.2** The EP component shall have the capability to trend data from all other components and the IAS archive.

Multiple plots (max #)/speed(?)
Variable time frames
Multi-variable plots
Flag, alarm out of limit performance values

***3.7.7.3** The EP shall have the capability to compare data items and parameters. (relate ??)

***3.7.7.4** The EP shall provide analysis tools to IAS analysts i.e. FFT, histogramming, statistical tools, curve fitting ..

speed (?), capacity (?)
muliti processing (?)

***3.7.7.5** The EP shall have capability to visually display images for inspection.

rotate, zoom, resolution (?), refresh rate(?)

3.7.8 Hardware Pieces (Processor, Tape Drive, Disk Drive...)

Here or in Design and construction 3.3

3.8 PRECEDENCE

3.9 QUALIFICATION

4.0 VERIFICATION

5.0 NOT USED

6.0 NOTES

6.1 GLOSSARY

0R: The stage in the processing prior to radiometric or geometric correction of an image and after the pixels have been placed in detector spatial order.

OR Product: Products distributed by the LPDAAC to include all bands ; 0R image data, browse data, metadata, radiometric calibration data, radiometric calibration coefficients, PCD, geometric processing parameters, and mirror scan correction data.

1R: The stage in the processing after radiometric correction has been applied to an image.

1G: The final stage in the processing after radiometric and geometric corrections have been applied to the image data.

Ancillary Data: Spacecraft attitude and ephemeris, radiometric correction coefficients, geometric processing parameters, and image quality statistics.

Archive: Permanent, off-line storage of data, software and documentation.

ASPAM : A model which creates a report on meteorologic conditions including such items as pressure, temperature and water vapor content as a function of altitiude, at a particular time and place, derived from empirical and interpolated data by USAFETAC (more than 48 hours after the fact).

Bright Target Recovery: Also known as memory effect

Calibration Activities: Recalculating of the radiometric correction coefficients or geometric processing parameters.

Data Storage: On-line storage of data accessible to the various functions within the IAS.

Dead Detectors: Non-responsive detectors.

Degraded Detectors: Also known as inoperable detectors (see definition).

Equivalent At-Aperature Radiance: Estimated radiance from other than full aperature radiance.

Entrance Aperature Radiance: Actual full aperature radiance.

ETM+ Equivalent Scene:
L0R Image Data (6320+225) x 5984 x 6 + ((12640 +450) x 11968) + ((3160 + 113) x 2992x2) = .41 GB
Level 1G, non-rotated, resampled to 25m (except Pan to 12.5m)
220km x 170km/(.025km/pix)^2 x 2bytes/pix x 7 bands +
220km x 170km/(.0125km/pix)^2 x 2bytes/pix = 1.3 GB

Geodetic Accuracy:

Geometric Accuracy: The accuracy with which the image data matches spatial relationships as they are on the earth.

Geometric Artifacts : Assessment of geometric artifacts (or assessment of geometric accuracy) includes visual assessment of discontinuities of linear features, scale distortion, panoramic distortion, and any other distortions.

Geometric Processing Parameters: Orbit parameters, instrument and alignment parameters, focal plane band locations, scan mirror profile coefficients (along scan and across scan), odd detector sample shifts, alignment matricies, ADS calibration parameters, gyro calibration parameters, along scan focal plane detector offsets, temperature calibration coefficients, inoperable modes,resampling coefficients, MTF coefficients and MTF compensation.
* Need to include parameters for the thermal band also.*
* Include also the short term file parameters such as Pole Wander data, UT1, UT2, and detector status*.

Ground Look Calibration: The process of radiometrically calibrating the payload, on-orbit, by comparing payload readings to estimated radiances reaching the payload from ground scenes using on-site ground and atmospheric measurements.

Ground Measurement Data: Also known as ground truth data.
- Normal image data of ground truth site collected in low gain mode.
- In-band target radiance measurements coincident with the Landsat 7 overpass.
- In-band irradiance measurements of the ground.
- Temperatures of the water at selected depths from the surface to one meter below the surface (for band 6 calibration)
- Air temperature and wind speed and direction just above the water temperature probes (for band 6 calibration).
- Atmospheric measurements to include: Pressure, temperature and relative humidity/water vapor density as a function of altitude as reported by radiosondes launched within on hour prior to the over pass of Landsat 7; Surface level pressure, temperature, and relative humididty/water vapor density; Surface level aerosol measurements and a ground visibility measurement within one half hour of the overpass; And Lidar measurements of water vapor density as a function of altitude within five minutes of the overpass.
- Full ASPAM report from USAFETAC for comparison.

In-Orbit Checkout (IOC): The 45 day period specified after launch during which spacecraft and sensor systems are activated, checked out, outgassed, and initially calibrated.

Initial Operational Capability (IOC): Milestone after satellite initialization and checkout wherein operations are transferred from the developers (NASA) to the system operators (NOAA).

Inoperable Detectors: Detectors meeting the following criteria shall be declared inoperable. a) The quantized digital number (DN) is below 50% of the full scale DN value when a detector is exposed to the ETM+ minimum satuation levels. b) The quantized digital number (DN) reaches full scale while the input radiance is at or below 0.70 times the ETM+ minimum saturation levels. orc) The signal-to-noise ratio (SNR) performance degrades to 50% or below the specified ETM+ minimum SNR values.

Level 1G Data: Includes both 1G imagery and geometric correction data.

Level 1G Imagery: Image data which has been geometrically corrected .

Payload Correction Data (PCD): The PCD contains all data required by ground stations to geometrically correct ETM+ sensor data and redundantly provides the ETM+ imaging configuration. The PCD is embedded in every wideband data VCDU at a rate of four bytes of PCD per VCDU. PCD data items are (1) Angular Displacement Sensor (ADS), (2) ADS Temperature (3) Gyro Data, (4) Gyro Drift Data, (5) Attitude Estimate, (6) Time of Last SV Clock Update, (7) SV Time Drift Characterization Data, (8) Ephemeris, (9) ETM+ Telemetry Data, (10) Spacecraft ID and Time Code, (11) Multiplexer Status, (12) PDF A/D Ground Reference, (13) Minor Frame Sync, (14) Major Frame Identification, (15) Spacecraft Identifier, (16) Attitude Control System Mode, (17) ETM+ On/Off Times.

Pre-launch Data :

Radiometric Processing Parameters: Includes the radiometry parameters in the calibration parameter file (pre-launch gains, intial post-launch gains, most current gains, detector status table, offset window locations, nominal biases, and scale factors) plus IAS maintained calibration parameters from individual calibration sources and the combined radiometric model (CRAM).

Radiometric Calibration Data:

Radiometric Image Artifacts: Striping, banding, scan correlated shift, bright target recovery response (aka memory effect), coherent noise, implulse noise, detector saturation and detector inoperability.

Test Sites:
Geometric test sites include 5 primary sites; Iowa (Path 28, Row 30), EROS (Path 29, Row 29), Texas (Path 28, Row 37), Northern Minnesota (Path 28, Row 27), Colorado Springs (Path 33, Row 33) and 3 secondary sites; Iowa II (Path 27, Row 30), Iowa III (Path 26, Row 30), Wichita (Path 28, Row 34).
Radiometric test sites include; White Sands Alkali Flats, NM (33N, 106W), Rogers Dry Lake Bed, CA (35N, 118W), La Crau, France (Lat, Lon??), Lake Tahoe, CA (40N, 120W), Libyan Desert (27N, 13E), Egyptian Desert (27N, 27E).

6.2 ACRONYMS

ACCA	Automated Cloud Cover Assessment
BER	Bit Error Rate
BRDF	Bi-directional Reflectance Distribution Function
CONUS	Continental United States/Contiguous United States
CRAM	Combined Radiometric Model
DEM	Digital Elevation Model
EDC	EROS Data Center
EROS	Earth Resources Observation System
ETM+	Enhanced Thematic Mapper Plus
FASC	Full Aperture Solar Calibrator
FHSERR	First Half Scan Error
GCP	Ground Control Point
GLC	Ground Look Calibration
GSFC	Goddard Space Flight Center
IAS	Image Assessment System
IGS	International Ground Station
IOC	In-Orbit Check Out or Initial Operational Capability
LGS	Landsat 7 Ground Station
LOS	Line-of-Sight
LPS	Landsat 7 Processing System
LPDAAC	Land Processes Distributed Active Archive Center
LSQAT	Landsat Quality Assurance Team
MMO	Mission Management Office
MOC	Mission Operations Center
MSCD	Mirror Scan Correction Data
MTF	Modulation Transfer Function
NBR	Navigation Base Reference
PASC	Partial Aperture Solar Calibrator
PCD	Payload Correction Data
PSO	Project Science Office
SBRC	Santa Barbara Research Center; Division, Hughes Aircraft
SHSERR	Second Half Scan Error
WRS	Worldwide Reference System

6.3 REQUIREMENT ALLOCATION MATRIX

6.4 SECTION 3.7 TO 3.2 RELATIONSHIPS